VOL. XVIII. MARCH, 1893. NO. 3.

THE BOTANICAL GAZETTE

EDITORS:

JOHN M. COULTER, University of Indiana, Bloomington, Ind.
CHARLES R. BARNES, University of Wisconsin, Madison, Wis.
J. C. ARTHUR, Purdue University, Lafayette, Ind.

CONTENTS:

On Monilia fructigena. (With plate VII.) *James Ellis Humphrey* . . 85
Non-parasitic bacteria in vegetable tissue.—*H. L. Russell* 93
A comparative study of the roots of Ranunculaceæ. (With plates II–IV. *Fred B. Maxwell* 97
Noteworthy anatomical and physiological researches 103
The plant cell and its organs.—*J. Christian Bay.*
Nutrition of insectivorous plants.—*J. Christian Bay.*
The phylogeny of ferns.—*D. M. Mottier.*
Briefer Articles 107
The flowers of the horsechestnut.—*Jane H. Newell.*
Francis Wolle.—*Editors.*
Another hybrid oak. (With plate VIII).—*A. S. Hitchcock.*
A graft hybrid.—*Herbert L. Jones.*
Current Literature 112
Notes and News 114

[ISSUED MARCH 20.]

BLOOMINGTON, INDIANA.
PUBLISHED BY THE EDITORS.

Tracy, Gibbs & Co., Printers, Madison, Wisconsin.

THE BOTANICAL GAZETTE.

A Monthly Journal Embracing all Departments of Botanical Science.

ANNUAL SUBSCRIPTION, $2.50.

SINGLE NUMBERS, 25 CENTS.

The subscription price is an invariable one, no concession being made to dealers or agents.

In Great Britain, 11 shillings.	In Germany, 11 marks.
Agent, W. P. COLLINS, 157 Great Portland St., London, W.	Agents, R. FRIEDLÆNDER & SOHN, Carlstrasse 11, Berlin, N. W. 6.

Subscriptions and business correspondence should be addressed to **JOHN M. COULTER, University of Indiana, Bloomington, Ind.**; money orders and drafts should be made payable to the BOTANICAL GAZETTE.

Separate Copies.— Contributors are furnished on request 25 separate copies of their articles (free) when 2 pp. long or more. Additional copies will be supplied at the following rates: For each 4 pages or less, per 100, $1.50; for each plate, per 100, $1.00. A less number at the same rate. Covers like GAZETTE, with title, $1.50 per 100, additional. *The number desired must be marked at the head of the MSS. as none will be printed unless ordered.*

Manuscripts.— MSS. and correspondence about publication should be addressed to **CHARLES R. BARNES, 712 Langdon St., Madison, Wis.** Contributors are requested to prepare MSS. exactly in the form in which they wish the article to appear, having due regard to the general style of composition shown in the pages of the GAZETTE. Scientific and proper names should be written with particular care.

Illustrations.— Correspondence regarding illustrations and advertisements should be addressed to **J. C. ARTHUR, Purdue University, Lafayette, Ind.**

Missing Numbers.—Will be replaced *free* only when claim is made within 30 days after receipt of the number following.

[Entered at the Post-office at Bloomington, Ind., as second-class postal matter.]

In the April number will appear:

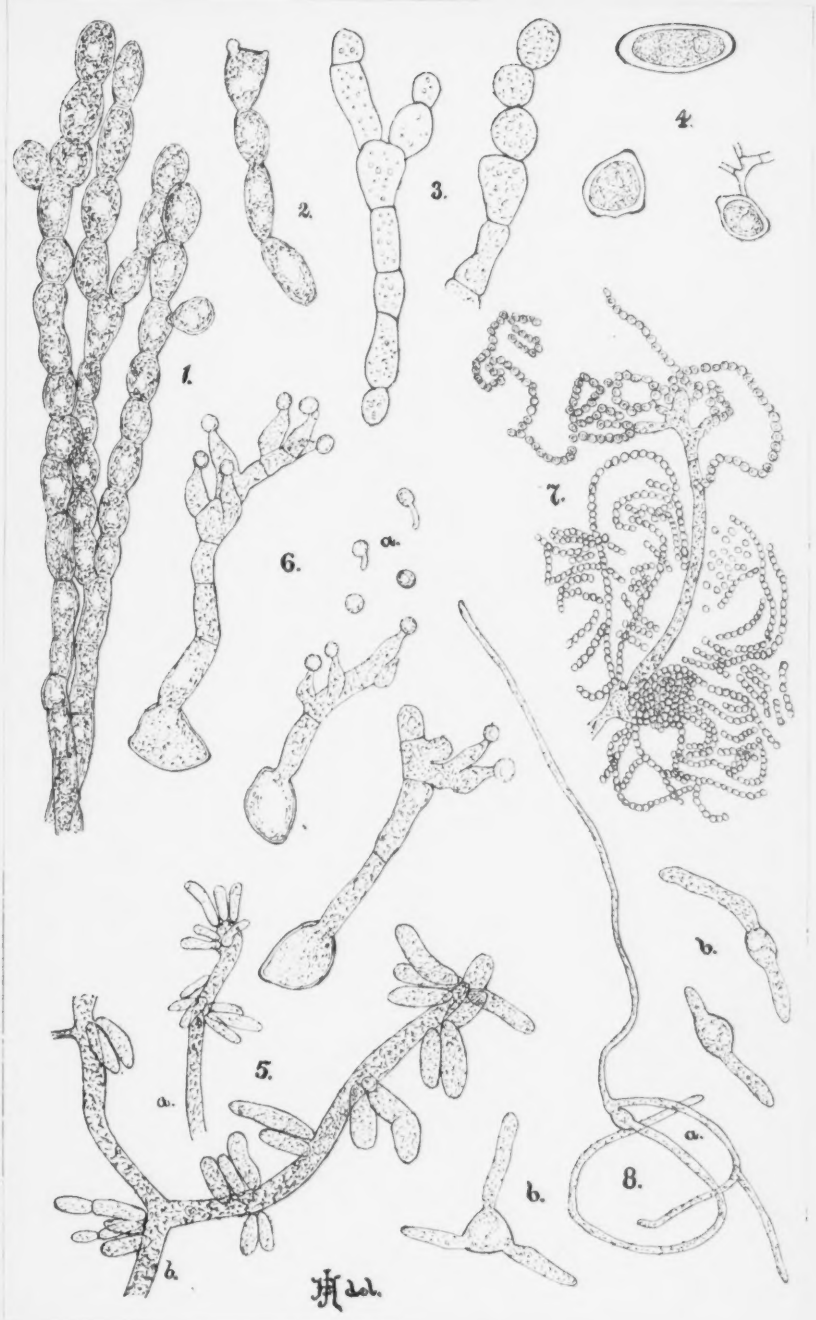
The limitation of the term "spore," by PROF. CONWAY MACMILLAN, *University of Minnesota.*

The genus Cæsalpinia, by E. M. FISHER, *University of Indiana.*

The tendrils of Passiflora cærulea, by D. T. MCDOUGAL, *Indiana Experiment Station, Purdue University.*

The range of variation in species of Erythronium, by MISS M. E. MEADS, *Olivet College.*

DR. ROLAND THAXTER'S **Note on Phallogaster saccatus,** announced for the March number but delayed at his own request, will be published in April.



HUMPHREY on MONILIA.

THE
JOHN CRERAR
LIBRARY

BOTANICAL GAZETTE

MARCH, 1893.

On Monilia fructigena.

JAMES ELLIS HUMPHREY.

WITH PLATE VII.

During the past fifteen years or more, attention has several times been directed, especially by American writers, to a parasitic fungus which causes great destruction of the fruits of certain cultivated *Rosaceæ*, chiefly *Pruneæ* and *Pomeæ*. It is most common on the stone-fruits, so that the affection to which it gives rise is ordinarily known in America as the "brown rot of stone-fruits." This fungus has been called by most recent writers *Monilia fructigena* Pers., but was earlier known as *Torula fructigena* Pers., *Acrosporium fructigena* Pers., *Oidium fructigenum* Lk., *Oidium laxum* Ehr., *Oidium Wallrothii* Thüm., and *Oospora fructigena* Wallr. It appears to have been first named *Torula fructigena* by Persoon[1], and was subsequently transferred by him[2] to the genus *Monilia*.

The plant was for a long time regarded as a saprophyte and von Thümen[3] and Hallier[4] seem to have been the first to point out its economic importance. Thümen subsequently[5] discussed its effects more fully, bringing out more prominently the evidence for its truly parasitic nature, and its claims to be regarded as a disease-producing organism. Yet the chief handbooks of plant diseases pass it with very brief mention or with none, and, even at present, it does not appear to be recognized in Europe as a source of loss to the extent that is fully justified by its ravages in America. Here it was first described by Peck,[6] in 1881, and by Arthur,[7] in 1884.

[1] Observ. Mycol., 1: 1796.
[2] Syn. method. Fung., p. 693: 1801.
[3] Oesterr. landw. Wochenbl., 1875, n. 41, p. 484.
[4] Wiener Obst- u. Garten-Zeitung, 1876, p. 117.
[5] Fungi Pomicoli, p. 22: 1879.
[6] 34th Rep't N. Y. State Museum, p. 35. See also 43rd Rep't do. p. 6.
[7] 4th Rep't N. Y. Agr. Exp. Sta., p. 254.

Subsequently its structure, as well as its disease-producing capacity and its means of dissemination and survival, have been studied by Galloway,[8] Smith[9] and the writer.[10] Various other accounts of its attacks, with recommendations as to the best means of avoiding them, have been published, chiefly in experiment station literature, and need not be more precisely quoted here. Neither need the results of studies bearing on the prevention or avoidance of the ravages of this fungus be discussed, since our present concern is with its structural relations.

The fungus, which, as Galloway[11] and Smith[12] have shown may attack foliage and young branches, as well as fruits, appears externally in the form of ashy tufts. Each tuft consists of a very large number of threads breaking through a common rift in the surface, and extending to a short distance in either direction from this center. These threads are much branched and consist of chains of ovate or oval thin-walled bodies, strung together in moniliform rows, which may be termed, in a general sense, spores (fig. 1).

The spores are formed, not by successive basipetal constrictions of a hypha, which has previously reached a determinate length, but by repeated budding in basifugal succession, so that the terminal joint or spore is the newest. Occasionally a joint may broaden at its end so that it has two apical angles, and may then produce a bud from each of these angles (fig. 2), thus giving rise to the dichotomous branching of the thread. It is in this way that the branches always originate. After the formation of a thread of greater or less length, according to circumstances, the separate joints or spores mature, and then separate from each other very readily. Thus, while the growth of the threads is indeterminate, their length does not become great in nature, apparently because the influence of the weather is to hasten their breaking up. But in a moist chamber, where these disintegrating forces are less active and the conditions favor very rapid growth, they may become extremely long.

The internal mycelium of the fungus consists of septate cylindrical hyphae, which ramify through the tissues of the

[8] Rep't U. S. Dep't Agr., 1888, p. 349.
[9] Journ. Mycol. v, 123, and vii, 36. 1890 and 1892.
[10] 8th Rep't Mass. Agr. Exp. Sta., p. 213: 1891.
[11] Loc. cit.
[12] Loc. cit.

host, and, breaking finally through its surface in fascicles, pass directly into the external spore-threads.

The mature spores germinate readily under the influence of warmth and moisture, and produce short threads which ordinarily perish after a few days in water that contains no available nourishment beyond that stored up in the spore. In a natural or artificial nutrient substratum the germ-tubes grow rapidly, penetrating and ramifying through the substratum and soon breaking out through its surface in tufts of spore-threads. Since the spores germinate so readily and are so thin-walled, it has been assumed that their vitality is of brief duration and that they constitute a so-called conidial stage of some fungus, perhaps one of the *Ascomycetes*. Woronin has suggested[13] that it may bear such a relation to some *Sclerotinia*. In the absence of knowledge of its affinities it has been classed among the imperfect fungi, being placed by Saccardo[14] in his *Mucedineae amerosporae*.

Smith has lately observed[15] that the spores retain their vitality, at least in some cases, for a long time; and both he and the present writer[16] have found that the dried tissues of fruits spoiled by the fungus contain a resting mycelium (fig. 3), and even definite thick-walled resting bodies or *gemmae* (fig. 4), probably developed from the mycelium. These resist long periods of unfavorable conditions and promptly give rise to new spore chains on the return of conditions favorable to vegetation. Thus, when a fruit that has been "mummified" by the fungus is gathered in winter or early spring, it commonly sends out new spore-chains of the *Monilia* type, on being placed in the moist chamber. And the same thing occurs spontaneously in nature when the weather becomes warm and damp enough, later in spring. These facts do away with a necessity for any other stage in the history of the plant and make it possible to believe in the autonomy of the form under discussion.

This, in brief, is the present status of our knowledge of the fungus. It is the object of this paper to describe and discuss the significance of certain previously undescribed structures

[13] Mém. Acad. Sci. St. Petersburg, VII. xxxvi, no. 6: 1888.
[14] Sylloge Fungorum, iv, 34.
[15] Journ. Mycol. vii, 36; 1892.
[16] Loc. cit.

that have been met with in the course of a series of cultures of the form. When a mummied fruit is placed in the moist chamber, it not infrequently happens that it fails to produce spore-chains, and to the unaided eye gives little evidence of any change. This occurs especially in late fall, soon after the cessation of vegetative activity. But if the surface of such a fruit be examined microscopically, it will usually be found that the mycelium of the fungus has given rise to immense numbers of closely-set, flask-shaped sterigmata, reminding one of those of *Aspergillus*. Each of these produces at its outer or neck end small globular spores of about 3μ in diameter, every one of which contains a conspicuous oil globule. One rarely finds more than one of these attached to the sterigma, but their vast number and the occasional observation of several still united shows that they must be produced in chains, like *Aspergillus* spores.

When some of these spores are sown on nutrient gelatine they germinate readily, first swelling to double their former diameter, and produce abundant mycelia (fig. 8). After a few days hyphae emerge from the surface of the gelatine and develop typical *Monilia* chains, thus demonstrating the specific identity of the two spore-forms. It is noticeable that these much condensed globular spores increase largely in volume on taking up nourishment, while the *Monilia* spores, originally much larger, undergo no increase in size.

A culture made in the fall of 1890, on prune-gelatine, with *Monilia* spores, at first produced the usual spore-chains and continued to grow until the nourishment contained in the small drop of gelatine was exhausted. At the end of a month from the beginning of the culture, during the whole of which the atmosphere of the moist chamber had been hardly at all disturbed, it was found that some of the chains remained still quite long, while some had broken up spontaneously into their constituent joints. Numerous separate spores lay about upon the surface of the shrunken and exhausted gelatine film or upon the supporting glass slide. Both of these surfaces were only slightly moist, but a number of spores were found to be germinating upon them. That they were the *Monilia* spores cannot be doubted, since they agreed completely in all respects with those still in chains near by. But under the conditions presented, of moderate moisture, lack of nourishment, and perhaps others not recognized as important, their

germination was quite different from the usual form. Each spore gave rise, from any part of its surface, to a single germ-tube, or very rarely to two, which became cut up by a few transverse septa. In most cases one or more of the basal cells remained sterile, while some or all of the others produced one or two flask-shaped outgrowths each. At the top of the neck of the flask were formed, in each case, globular spores, 2.5 to 3μ in diameter, of which not more than one was ever seen attached (fig. 6). These spores were also found fallen from their attachments and beginning to germinate (fig. 6, *a*). In other words, these germ threads from the *Monilia* spores produced precisely similar structures to those which we have seen to be sometimes produced by the resting mycelium at the surface of the natural substratum. While these spores can germinate without nourishment, they suffer no preliminary increase in size. On prune-gelatine they swell and germinate as above described. Though their development could not be followed through, there is no reason to doubt that it agrees with that already outlined for this spore-form.

On another occasion, a stout hypha in a culture on prune-gelatine was observed to produce, at the ends of short branches and on slight outgrowths from its sides, long chains of similar globular spores. In this case the spore-chains, having been quite undisturbed, could be plainly recognized, though they readily fell into short sections or into their component spheres (fig. 7). In spite of the absence of distinct sterigmata, it seems probable that this is essentially the same form as the previously described one, since the spores are produced in the same way, are of about the same size, and contain the characteristic oil-globules.

When *Monilia* spores are sown directly upon the surface of nutrient gelatine, they quickly develop a mycelium and spore-chains, as has been said. Several times I have observed, in cases where some spores had been sown a short distance beyond the edge of the gelatine drop, that the threads from them, growing slowly toward the drop, when they finally reached it began, as was to be expected, to grow much more rapidly. But, instead of remaining naked threads, they produced, by a sort of budding from various points or from nearly all points along their sides, oblong bodies, as shown in fig. 5. Sometimes these bodies were far more abundantly produced than is shown in the figure, so that they almost

completely filled the gelatine over considerable areas. Unfortunately, their future fate and their capacity for germination were not determined; but that they belong to the *Monilia* cannot be doubted, since the threads which gave rise to them were seen to originate from *Monilia* spores in pure culture and the same threads were traced through the gelatine to points where they emerged from the surface and became *Monilia* chains.

In examining the significance of the phenomena described, we are led first to ask how the various structures described are to be regarded. It is evident that the spores of the *Monilia* chain are not conidia in the truly morphological sense in which Brefeld uses[17] the term. That is, they are not spores produced in fructificative fashion on specialized spore-bearing threads. They are simply slightly individualized portions of mycelium with the form and physiological characteristics of spores. Though differing in the details of their development from the spore-chains of the *Erysipheæ* which constitute the old genus *Oidium*, they are morphologically similar to them. And indeed, as above noted, some writers have included the present plant under that generic name. As Brefeld has shown, all these "Oidien-ketten" are to be regarded as the simplest type of chlamydospore formation. A consistent terminology will, then, designate the common spores of *Monilia fructigena* as chlamydospores of the most primitive type, for which we may retain the name *Oidium*. But the name must be understood in a morphological and not in a systematic sense.

In view of the incompleteness of our knowledge of the oblong bodies described last and shown in fig. 5, it seems best merely to record their occurrence and to await fuller information as to their early and subsequent history, before attempting any discussion of their significance. While it seems probable that they have reproductive capacity, there is little evidence on this point either from their own development or from analogy, since one hesitates to homologize them fully with other described organs of fungi.

On the other hand, the spores of the second form above described are produced on distinct, if short, sporophores and

[17] Unters. aus dem Gesammtgeb. d. Mykol., 7, 244. This clearly marked and fundamentally important distinction between the conidium and the chlamydospore must be generally recognized.

constitute a true fructification. They are, in any point of view, to be called conidia. Furthermore, the homologies of this form seem to be clear. Tulasne[18] has figured similar structures which he observed on the mycelia of *Peziza (Sclerotinia) tuberosa* and of the closely related *P. bolaris* and *Durieuana*. Brefeld[19] has found them in his cultures of *Sclerotinia tuberosa* and *Libertiana*, and DeBary[20] has seen them in the latter species and *Scl. Fuckeliana*. Zopf[21] saw very similar structures on the mycelium of *Chaetomium*, and Woronin[22] in *Sordaria*. In all of these cases the general structure and mode of development of these conidia is the same. Tulasne found them rather sparingly produced on young germ-tubes developed without extraneous nourishment, just as did the writer in one instance. Brefeld and DeBary obtained them very abundantly in cultures on nutrient media, which was once the writer's experience. When developed from a resting mycelium, they are produced almost as abundantly as on nutrient media. Neither of the writers mentioned above was able to observe the germination of these spores, and they were classed by DeBary[23] as "doubtful spermatia," under the influence of his well known views concerning the typically sexual character of the *Ascomycetes*. It is certain, however, that the conidia associated with *Monilia fructigena* germinate readily and produce a mycelium and *Monilia* chains, as above described. This fact makes it probable that the corresponding forms associated with other fungi, especially with *Sclerotinia* species, are also to be regarded both morphologically and physiologically as microconidial stages, although the conditions of their further development still remain unknown.

In his study of the several species of *Sclerotinia* which attack the leaves and fruits of European *Vaccinium* species, Woronin[24] found a chlamydosporic stage of *Scl. Vaccinii* that very closely resembles that long known as *Monilia* or *Torula fructigena*. His form is in some respects more highly differentiated than the latter, especially in its development of

[18] Selecta Fungorum Carpologia, III, t. 22: 1865.
[19] Bot. Unters. über Schimmelpilze, IV. 113; t. 10: 1881.
[20] Comp. Morph. and Biol. Fungi: 1884; Eng. trans., 243.
[21] Nova Acta A. C. L.-C. N. C. XLII, no. 5: 1881. Also, Die Pilze, 453: 1890.
[22] Beitr. z. Morph. u. Phys. d. Pilze, III: 1870.
[23] Loc. cit.
[24] Ber. d. D. Bot. Gesell., III, p. lix: 1885. Also, Mém. Acad. Sci. St. Petersburg, VII. XXXVI, no. 6: 1888.

cellulose plugs between the spores, which by their growth force the spores apart and so serve to disseminate them. This plug, called by Woronin the disjunctor, is not in any way represented in *M. fructigena*. Yet the whole habit of growth and the general mode of spore-formation is so similar in the two forms as amply to justify Woronin's suggestion of their possible near relationship. The probability of the correctness of this idea is still further increased by the observation of the microconidial stage above described, although none such is mentioned by Woronin as belonging to either species of the group of *Sclerotinia Vaccinii*. For the occurrence of such a stage in the commonest and best known species of *Sclerotinia* with conidia of the *Botrytis* type[25] affords ground for the belief that another species possessing it may be a *Sclerotinia*, also; and the combined evidence of the microconidial and chlamydosporic stages is very strong. Assuming for the moment that the forms above described are imperfect stages of a *Sclerotinia*, the microconidial form connects the two groups of the genus in an interesting way, bringing more closely together those possessing macroconidia of the *Botrytis* type and those whose "summer-spore" stage is a chlamydosporic one of the *Monilia* type.

As to the actual existence of a perfect form of *Sclerotinia* to which our *M. fructigena* belongs, it can only be said that in the examination of a very large number of fruits in all stages of disease from the attacks of *Monilia*, at all seasons, the writer has never seen any trace of sclerotia or spore-cups; nor have any such been mentioned by other writers. It seems, therefore, pretty certain, in view of the attention that the fungus has received in recent years, that the development of such structures is exceedingly rare, at least. As has been pointed out above, the fungus commonly perpetuates itself by means of its resting mycelium, and the development of sclerotia is therefore wholly unnecessary to the preservation of the species. One may therefore be quite justified in the belief that in *Monilia fructigena* we have the persistent chlamydosporic and microconidial stages of a *Sclerotinia*, allied to *S. Vaccinii*, whose perfect stage has become practically or entirely suppressed.

[25] I shall show in the forthcoming report of the Massachusetts Agricultural Experiment Station that it is probable that *Scl. Libertiana* possesses such a conidial form.

I have not been able to examine the large number of forms included by Saccardo under *Monilia*. Of these it is probable that many have no real affinity with that above discussed; while others may be closely related. Such appears to be the case with a rather common form which attacks the immature fruits of *Prunus serotina* and related species, forming delicate white tufts, with spores very like, but somewhat smaller than those of *M. fructigena*. This is probably the plant called by Saccardo[26] *Monilia Peckiana*, var. *angustior*. The few cultures I have been able to make have yielded only the common spore-chains, but the form will probably repay further investigation as to its pleomorphism and its affinities.

Weymouth Heights, Mass.

EXPLANATION OF PLATE VII.

Fig. 1. Two *Monilia* hyphæ passing into branching spore-chains. ×540.
Fig. 2. The end of a spore-chain, showing the origin of branching from two terminal angles of the terminal cell. ×540.
Fig. 3. Bits of resting mycelium from the flesh of a "mummied" plum. ×540.
Fig. 4. Resting cells, "*gemmæ*," from the same source. ×540.
Fig. 5. Hyphæ from *Monilia* spores, with oblong bodies developed within the gelatine. *a*, ×540. *b*, ×940.
Fig. 6. Three *Monilia* spores producing germ-tubes with sterigmata and microconidia. *a*, germinating conidia. ×940.
Fig. 7. Chains of microconidia from *Monilia* hypha, in culture. ×540.
Fig. 8. Microconidia germinating on nutrient gelatine. *b*, after one day, ×940. *a*, after 2 days, ×540.

Non-parasitic bacteria in vegetable tissue.[1]

H. L. RUSSELL.

It has been ascertained that the tissues of the animal body in their normal healthy state are perfectly free from bacteria but the evidence that the same is true in regard to vegetable life is not so unanimous. The subject has received considerable attention at the hands of bacteriologists and while the majority of observers do not admit that bacteria are to be found in vegetable tissue in a healthy state, some proof has been brought forward to support such a conclusion[1].

In a course of experiments, which have been carried on for

[26] Sylloge Fungorum, IV, 34.
[1] Read at the Rochester meeting of the A. A. A. S., August, 1892.

some time in another connection, I have noted a number of points that seem to have a direct bearing on this question and afford a possible explanation for the contradictory evidence previously at hand.

The effect of the inoculation of various saprophytic as well as facultative parasitic species of bacteria into the tissue of different plants was studied in order to determine first, the effect produced on the plant, if any, and second, the reciprocal effect on the micro-organism.

Caulescent plants,[2] such as Geranium, were selected and into these were injected various forms of micro-organisms, after washing the stem with sterile water to rid it as far as possible of the bacteria on its surface. The minute opening in the stem caused by the inoculating needle was closed by sterile vaseline, so as to prevent the entrance of foreign organisms. In this way different species of bacteria were introduced into the interior of rapidly growing healthy plants, and after varying periods of incubation, their effect was ascertained. With certain saprophytic forms such as B. megaterium, B. lactis aërogenes, B. butyricus, etc., as well as those species pathogenic for animals like B. anthracis, B. typhosus, B. diphtheriae columbarum, no macroscopic change could be detected in the tissue of the host when it was in a healthy growing condition. Of course those forms that are pathogenic for plants, such as pear blight, did affect their respective hosts when inoculated into susceptible plants, but when species not closely related to their normal hosts were used, no macroscopical change could be noticed in the condition of the plant. A microscopical examination of the tissues also failed to reveal any pathological conditions brought about by the injection of the micro-organisms.

So much for the effect of the micro-organism on the plant.

The effect of the host upon the micro-organism was, however, greatly different. This was determined by means of culture experiments. The plant tissue into which the bacteria had been injected was taken after varying periods of incubation and the cortical ring of tissue removed by sterile scalpels, after which quite thin transverse sections of the remaining core of tissue were sectioned, also under aseptic precautions. These were then seeded in melted gelatine tubes

[2] Fazio: Revista Intern. d'Igiene (1890); Galippe, and others.

and roll cultures made therefrom. The liquefied gelatine penetrates the section and the bacteria present are able to grow. Not only were cultures made in this way from the tissue taken at the point of inoculation but sections were also taken at varying intervals both above and below the point of introduction. Special care was taken in the use of germ-free instruments, so that there was no possibility of transferring bacteria from one section to another.

The results obtained in this way were quite various. Nearly all of the species pathogenic for the animal body, as B. anthracis, B. diphtheriae, B. cholerae gallinarum, Micrococcus tetragenus, M. cereus flavus, Staphylococcus epidermis albus and St. pyogenes aureus, were killed out in the plant tissues after a lapse of a few days. One notable exception was, however, observed in the case of B. pyocyaneus. This germ was able to live in healthy plants of different species like Geranium, Penthorum and Begonia for 50 to 70 days or more and even able to spread throughout the plant tissue in an upward direction to a distance of 50 to 80^{mm}. By far the greater number of the parasitic bacteria, however, were unable to survive in the plant.

With saprophytic bacteria, the case was usually different. B. prodigiosus, B. butyricus, B. luteus, B. coli communis, B. fluorescens, and the lactic acid germ were all to be found in large numbers after varying periods of incubation ranging from 20 to 50 days, not only at the point of inoculation but in gradually lessening numbers for some distance up the stem.

Other species like B. megaterium and B. lactis aërogenes were to be detected in the tissue after 40 days but only in small numbers and *only* at point of inoculation.

Now these results indicate that bacteria, saprophytes at least, can live in the tissue of plants for a considerable length of time, and the fact that they are able not only to exist at the point of introduction but to spread throughout the tissue to a limited extent raises the question as to whether they are not really able to grow, to a limited extent at least, if they once gain access to the less resistent tissues of the inside of the plant.

On this point, enough data have not yet been gathered to say definitely, but these observations are presented with ref-

erence to the first question raised, as to the presence of bacteria in normal healthy tissues.

It has been shown that certain bacteria *can* live in plant tissues for a long time, if they are once allowed an entrance (as by artificial inoculation). What happens by artificial inoculation can under certain circumstances also take place in a state of nature. If by any means, a plant is wounded in any way, bacteria can enter from the air, and if the tissues are succulent enough, they can at least live for considerable time. Bacteria introduced in this way as wound parasites would come to be enclosed in the tissue by the healing over of the wounded surface, and thus error might arise as to their origin even if the experiments were carried out on the most rigid of bacteriological principles. A minute puncture would suffice to allow them to enter, as was to be seen when a sterile platinum needle was thrust into the tissue of a stem and then the wound closed by vaseline as before. Cultures from the pith parenchyma showed bacteria that were also to be found on the epidermis of the plant.

In connection with the above results, I have made numerous attempts to isolate micro-organisms from different forms of vegetable tissue, where I first made sure that there were no wounds, but in no case have I been able to isolate them where the conditions of the experiments were faultless. The appearance of a single colony or so in the cultures occasionally, is due to the inevitable exposure at the time of preparation of cultures. The danger of external contamination is much less where stems of fairly good size are used instead of such subterranean organs as rhizomes. Bacteria are present in the superficial soil layers in myriads and it is easy to see that by some slight abrasion or puncture of the epidermis they can gain access to the inner tissues of the plant and here live for a considerable length of time.

The evident conclusion from these results is that vegetable like animal tissue is normally free from micro-organisms, but that in healthy plant tissue many species of bacteria are able to exist for a not inconsiderable length of time. This is true with the most healthy growing plants, and where the vitality of the plant is weakened to any great extent, the micro-organism is much more able to sustain itself in the struggle for existence.

University of Chicago.

A comparative study of the roots of Ranunculaceæ.

FRED. B. MAXWELL.

WITH PLATES II—IV.

(Continued from p. 47.)

V. A study of the meristem.

In the studies thus far made, the roots of *Ranunculaceæ* have all been assigned to one type, as regards their apical meristem structure, this being Erickson's third type and Janczewski's fourth. My investigations indicate that the roots do not all follow this type, some agreeing with Janczewski's third type, and on account of a modification of structure for two species, I have provisionally formed another subsidiary type.

I have not thought it necessary to describe and figure the meristem of each particular species, but will define the type, describe one representative species under it and then name the other species found to agree with this type.

1. My first type includes roots having three primary meristem tissues, the plerome, the periblem, and, in Erickson's phrase, the dermocalyptrogen, the root-cap and epidermis having a common origin. This will be seen to be Janczewski's third type, corresponding to Erickson's first type for dicotyledons. As an example of this type I describe the structure of the root tip of *Ranunculus sceleratus*.[1] In this root the epidermis can be traced from above the root-cap, thence passing beneath its layers, and ending as a distinct layer at a point near the tip of the central cylinder, as shown at *a* in the figure: at this point the cells lose their epidermal character, divide and merge into the tissue of the root-cap; the cortex, however, is distinct from the tissues on either side even at the tip, though here it is reduced to about two rows of cells, and presents an initial group of its own; likewise the central cylinder is distinctly separated from the cortex by a continuous endodermis, its initial group consisting of a few cells at the tip, thus presenting, as already pointed out, a plerome, *pl*, a periblem, *p*, and a combined initial group for the epidermis and root-cap, the dermocalyptrogen, *dc*. The other species found to agree with this in structure are: *R. circinatus*, *R. aquatilis* var. *trichophyllus*, *Clematis*

[1] Plate IV, fig. 30.

verticillaris and probably *R. repens*, *R. bulbosus* and *R. fascicularis*, though in the last three species the roots at the very tip show to a certain degree a blending of tissues, and perhaps the plerome and periblem could be said to coalesce with the dermocalyptrogen and so belong to Erickson's third type. He certainly says *R. repens* belongs there, but my sections would indicate that the plerome and periblem were distinct in origin though slightly confused by later growth.

The roots of two plants examined differed from the first type only in that the epidermis can be traced as a distinct layer entirely about the periblem, while in the first type the epidermis ended as a distinct layer before the vegetative point was reached. In this, as in the first type, the root-cap is derived from the epidermis, for though the epidermis can be traced entirely around the vegetative point, it gives off layers of cells which are distinctly a part of the root-cap. This variation from the first type is so slight as to warrant us at most in simply establishing a subsidiary type. The structure for this subsidiary type is shown for *Ranunculus Pennsylvanicus* in plate IV, fig. 31. The epidermis is distinctly traced both by its peculiar appearance and by being a continuous, unbroken layer entirely about the tip of the cortex; the origin of root-cap cells from this layer is indicated at *a* and *b* of the figure; the cortex is of several rows of cells which are reduced to two at the tip and do not coalesce with either the epidermis on one side or the central cylinder on the other. Thus we find a distinct plerome, *pl*, and periblem, *p*, and a combined dermocalyptrogen, *dc*. It differs from the first type only in that the epidermis does not lose its identity, though giving birth to the root-cap by cell-division on its exterior side. The only other plant I certainly place in this provisional type is *R. acris*. Other species with doubt referred to the first type may possibly belong to this subsidiary type.

2. My second main type corresponds to Erickson's third type in which all the tissues merge into one at the vegetative point, that is, the initial group is a common one for all tissues. As an example of this type I have taken the root tip of *Aconitum Noveboracense*.[2] In this root the epidermis is seen to be of cells which are larger than the other cells of the root tip, and can be traced from above the root cap, thence

[2] Plate IV, figs. 32, 33.

beneath its upward projecting layers, but ending as a distinct layer at about 1^{mm} from the tip of the central cylinder, represented at *a* in the figure. Here the layer loses its epidermal character and divides to merge into the tissues of the root cap, as in the first type, the cortex of several rows of cells could be traced as distinct layers to within about 5^{mm} of the tip of the central cylinder where they divided irregularly and appeared to coalesce with the epidermal[3] and root cap tissues of this region, as shown at *b* in the figure, the central cylinder as bounded by the endodermis was distinct to within a small fraction of a millimeter from the tip, where its rows of cells ended as distinct rows and its tissues merge into those of the cortex, as shown at *i* in the figure. Thus we see that all the tissues run together at the vegetative point and the initial group is a common one.

In this type I also include : *Anemone Virginiana* and its var. *alba*, *Actæa alba*, *A. spicata* var. *rubra*, *Hepatica acutiloba*, *H. triloba*, *Cimicifuga racemosa*, *Hydrastis Canadensis*, *Trollius laxus*, *Thalictrum dioicum*, and perhaps *Ranunculus septentrionalis*, though in this latter case the plerome and periblem almost appeared to be distinct, and if so it belongs to the first type.

While I have made these three types of meristem structure for the roots of *Ranunculaceæ*, my examination has shown me that there are no hard and fast lines circumscribing these types but there are all gradations between the structure as found in *Ranunculus Pennsylvanicus*, in which the epidermis could be traced distinctly about the vegetative point, to that found in the roots of *Aconitum Noveboracense* in which the tissues quite evidently coalesced at the vegetative point. It will be seen that the larger number of species are placed in the second main type, which is the type to which the *Ranunculaceæ* studied by Erickson and Flahault were assigned, these writers being the only ones, as far as I have been able to find, who have studied the meristem of any of the *Ranunculaceæ*, and the few species they studied were mainly those not found in this country.

Of some of the species taken for study, I was unable to obtain sections of the vegetative point that showed the meristem

[3]The epidermis in this as in most of the roots studied stained differently and had an entirely different appearance, and could easily be distinguished from any other tissue.

structure, some on account of the very minute root tips, as *Anemone thalictroides* and *Coptis trifolia;* others failed of success since the material first gathered proved to be poor and then the ground had become frozen and I was unable to obtain more material. Among these latter plants, are *Thalictrum polygamum, Anemone Pennsylvanica, Ranunculus recurvatus, Clematis Virginiana, Aquilegia Canadensis* and *Caltha palustris.*

The assigning of the species to the types as I have placed them may be but provisional, for though I had sections of several root tips from each species in almost all cases, yet sometimes two sections from different roots of the same species did not appear exactly alike in their terminal structure, and a study of a greater number of roots might necessitate changing some plants from one type to another, but they certainly do not all fall under one type of structure,[4] as indicated by Erickson.

VI. Summary.

1. *Changes through secondary growth.*

In discussing the differences found in the several species of *Ranunculaceæ* examined, I have made three types of structure on the basis of the changes taking place through secondary growth.

First, those plants which show no marked change of root structure, the primitive radial type of structure persisting in the older roots. In this class I include *Ranunculus acris, R. Pennsylvanicus, R. recurvatus, R. septentrionalis, R. hispidus, R. fascicularis, R. bulbosus, R. multifidus, R. circinatus, R. aquatilis* var. *trichophyllus, Hepatica acutiloba, H. triloba, Aconitum Noveboracense, Trollius laxus,* and *Caltha palustris.*

Second, those plants showing a greatly marked change in the bundle area through growth of secondary xylem rays, which by their great development conceal the primitive radial type as found in the younger roots. To this class belong *Clematis Virginiana, C. verticillaris, Cimicifuga racemosa, Actæa alba, A. spicata* var. *rubra, Anemone Virginiana* and its var. *alba, A. Pennsylvanica, Coptis trifolia, Hydrastis Canadensis* and *Ranunculus sceleratus.*

Third, those plants which show in the older roots a great

[4] My study has all been upon the mature root.

development of the central cylinder and a corresponding decrease of the cortex region. This change is partly brought about by the increase of conjunctive parenchyma in the central cylinder, the xylem being all collected at the center and the phloem in several scattered rays radiating from this center. But the decrease in the cortex region of the oldest roots is mainly due to exfoliation, the epidermis and in some cases all but two rows of the cortex cells being thrown off, so that the endodermis, consisting of many very small regular cells whose walls are generally cutinized, now serves the purpose of an epidermis. This exfoliation was especially noted in the Thalictrums studied. In this type are placed but four of the plants that came under my study, viz.: *Thalictrum dioicum*, *T. polygamum*, *Anemonella thalictroides* and *Aquilegia Canadensis*.

2. *Meristem of vegetative point.*

I have found that the roots of the *Ranunculaceæ* do not all fall under one type of apical meristem structure, but that there are two main types and a possible subsidiary type to be recognized in these roots.

First, a type having a distinct plerome and periblem and a combined dermocalyptrogen. In this type I have placed *Ranunculus sceleratus*, *R. circinatus*, *R. aquatilis* var. *trichophyllus*, *Clematis verticillaris*, and probably *R. repens*, *R. fascicularis* and *R. bulbosus*.

Subsidiary type, like the first type except that the epidermis is a distinct layer entirely about the vegetative point, though giving birth to the root-cap and so having the same initial groups as the first type. Here are included but two species, *Ranunculus acris*, and *R. Pennsylvanicus*.

Second, a type in which all the tissues coalesce at the vegetative point, having but one, and this a common, initial group. This type includes the greater number of species studied and is the type in which Erickson and Flahault include the *Ranunculaceæ* studied by them. The species placed in this type are *Aconitum Noveboracense*, *Anemone Virginiana*, and its var. *alba*, *Actæa alba*, *A. spicata* var. *rubra*, *Hepatica acutiloba*, *H. triloba*, *Cimicifuga racemosa*, *Hydrastis Canadensis*, *Trollius laxis*, *Thalictrum dioicum* and perhaps *Ranunculus septentrionalis*.

VII. Acknowledgment.

The work for this article was done under the personal supervision of Prof. Wm. R. Dudley, then of Cornell University, and I have to thank him greatly, not only for the assistance he rendered me in looking up the literature of the subject, and especially in the collection of material, but also for his kindly supervision of the progress of the work.

Chicago.[5]

Explanation of Plates II–IV.

Abbreviations used: *e*, epidermis; *c*, cortex; *en*, endodermis; *c c*, central cylinder; *x*, xylem; *ph*, phloem; *pl*, plerome; *p*, periblem; *d c*, dermocalyptrogen.

All figures of transections of roots were from camera lucida drawings; of other figures the outline was from camera lucida drawings and the details were put is free hand. The scale of magnification is indicated with most figures, the line drawn being the magnification of .1^{mm} for the lower powers of the microscope, and of .01^{mm} for the higher powers. Of the drawings of transections of the roots shown in figs. 1 to 25, two drawings have been made of each section, one from a higher power of the microscope, showing the central cylinder, with the xylem and phloem masses, *x* and *ph*, the surrounding conjunctive parenchyma, the enclosing endodermis, *en*, and generally one or more rows of cortex cells, *c*; the other from a ¼^{in} objective simply to show general plan of structure, and relative proportion of cortex and central cylinder, hence only part of the cells are drawn.

Plate II.—Figs. 1, 2. Ranunculus aquatilis, var. trichophyllus.—Figs. 5, 6. Ranunculus circinatus.—Figs. 5, 6. Ranunculus acris.—Figs. 7, 8. Ranunculus hispidus.—Figs. 9, 10. Ranunculus fascicularis.—Figs. 11, 12. Ranunculus multifidus.

Plate III.—Figs. 13, 14. Hepatica acutiloba.—Figs. 15, 16. Anemone Virginiana.—Figs. 17, 18. Caltha palustris.—Figs. 19, 21. Actæa alba, young root.—Fig. 20. Actæa spicata, var. rubra.—Figs. 22, 23. Aconitum Noveboracense.

Plate IV.—Fig. 24. Clematis Virginiana, older root.—Fig. 25. The same, young root.—Fig. 26. Cimicifuga racemosa, young root.—Fig. 27. The same, older root.—Fig. 28. Thalictrum polygamum, young root.—Fig. 29. Thalictrum dioicum, older root.—Fig. 30. Ranunculus sceleratus, root tip.—Fig. 31. Ranunculus Pennsylvanicus, root tip.—Fig. 32. Aconitum Noveboracense, root tip.—Fig. 33. The same, diagrammatic figure.

---

[5] At the close of the two preceding parts of this paper strike out the words *University of*, as the author has no connection with the University of Chicago.

Noteworthy anatomical and physiological researches.

The plant cell and its organs.

In 1892 three important papers were published on cellular structure, while smaller papers and contributions were issued abundantly. From Sachs[1] we have a short paper; from Bütschli[2] and Wiesner[3] extensive books. The fundamental organ in the cell, according to Sachs, is "the nucleus, with that part of the protoplasm which surrounds it and governs it," and this organ is called an energid. Plurinuclear cells, therefore, are easily understood to be a system of organs, since these cells contain more than one energid, and the growth of the number of energids determines growth in general. In the continuation of his "Arbeiten" Sachs promises to give a full account of this theory.

Like Berthold,[4] Bütschli regards the protoplasmic structure as an emulsion, and in proper mixtures he has been able to produce his "Schäume," which, when microscopically examined, appear to have a structure very much like that of the protoplasm, though, as Wiesner shows, the two do not result from the same molecular forces. Consequently Bütschli sees in the process of intussusception only diffusion.

Wiesner reviews at length the theories of Schwann,[5] Nägeli,[6] Pfeffer,[7] Berthold, Strasburger,[8] and Altmann,[9] concerning cellular anatomy and physiology, and shows logical reasons why neither of these can be held as generally applicable. After showing, in a historical introduction, how the elementary structure and the growth of the living substance have been explained by previous authors, he states his own position in the following words:

"Between the visible structure of the organism and the molecular structure which is common to all matter, is an or-

---

[1] Zur Zellentheorie. Flora, 1892. p. 58–63.

[2] Untersuch. üb. mikroskop. Schäume und das Protoplasma. Leipzig, Engelmann. 1892. 4°. 24 Mark.

[3] Die Elementarstruktur und das Wachsthum der lebenden Substanz. Wien. Holder. 1892. 6 Mark.

[4] Studien über Protoplasmamechanik. Leipzig. 1886.

[5] Mikroskopische Untersuchungen. Berlin. 1839.

[6] Die Stärkekörner. Zürich. 1858.

[7] Osmotische Untersuchungen. Leipzig, 1877, and Pflanzenphysiologie, I. 1881.

[8] Histologische Beiträge II. Ueber das Wachsthum der Zellhäute. Jena, 1889.

[9] (a) Die Genese der Zelle. Leipzig. 1887; (b) Archiv f. Anat. und Physiol. 1889 (structure of nucleus); (c) Die Elementarorganismen. Leipzig, 1890.

ganization of the simplest kind, and this I call the elementary structure." The visible structure of living beings may be studied up to a certain point, as it has been, yet it becomes almost necessary to have a further theoretical basis for the explanation of the many important results reached in the physiology of the vegetable cell, and this is furnished by the "plasome" of Wiesner. His theory has its foundation in the phenomena of division in the vegetable kingdom. Organized individuals, like nuclei, chlorophyll grains, plastids, etc., are not the elementary organisms in his mind, but, as all visible organic units in the cell are propagated by division, it is assumed that the elementary organs or plasomes are also formed and propagated this way. These plasomes "hold the specific properties of the living substance, undergo division, grow, and assimilate." Wiesner's book is written in admirable language, and will be of interest to both botanists and zoologists. It contains many useful notes, and may be regarded as being, in many respects, as important a contribution as Nägeli's "Stärkekörner" was.

Loew and Bokorny published[10] a very interesting paper, "*Zur Chemie der Proteosomen*," which claims the correctness of earlier investigations against Klemms' objections. In the *Biologisches Centralblatt* XI, 5, and in *Nature* XLVI, 491, brief articles have been published on the same subject. The present paper deals almost exclusively with the "proteosomes," *i. e.*, globular masses formed in the living cells of a great many plants—*Spirogyra*, pistils of *Eugenia*, young leaves of *Mimosa pudica* and *Nymphæa Zanzibarensis*, young petals of *Drosera*, *Cyclamen*, *Tulipa*, etc.—when these are treated with a 0.5 per cent. solution of coffein or antipyrin. The proteosomes consist of "active albumen" which shows all the characteristic albumen reactions. In a Spirogyra thread the proteosomes are very easily seen when the cells are treated twenty-four hours with the solution of coffein, in which the plants keep alive for a number of days. In dead cells, however, the proteosomes have not the same properties as those mentioned above; while the globules of living cells are easily dissolved in water of 25°–30° C., those of the dead cells remain unchanged, and "display all the properties of common coagulated albumen." This latter form of proteosomes consist of "passive albumen."

[10] Flora, 1892. Ergänzungsband, p. 117–129.

These data can very easily be verified, and they are very instructive. Another question is, whether the "active albumen" is in any way connected with the "vital power" itself, and if we have here a reaction, from which we may judge whether life is present or not. The aldehyde theory, when employed here, can explain the vital power, but it seems a little incomprehensible that the vital power should merely be based upon chemical processes. Still, whether the theoretical deductions are provable or not, we have in Loew and Bokorny's investigations a very important contribution to cellular physiology.

In spite of the many efforts to the contrary, the door is being gradually opened to cellular and molecular physiology. Logical definitions and improved methods will be a mighty support. We have no doubt that the way to molecular physiology will be through the phenomena of the *cell-life* on one side and through the phenomena of *movement* on the other hand, and we shall see more and more clearly that "there is only one kind of life and one kind of physiology for all beings."—J. CHRISTIAN BAY.

Nutrition of insectivorous plants.

N. Tischutkin made a series of investigations on the activity of micro-organisms in the nutrition of insectivorous plants,[14] which shows that in the secretion of insectivorous plants the proteid substances are altered through the influence of micro-organisms, especially bacteria; that such organisms are always living in the fluid excreted by fully developed insectivorous plants; that the process of digestion does not begin with the beginning of excretion of the digestive solution and does not occur until a sufficient number of micro-organisms are present; that the organisms effective here come from the air or from other sources; and lastly, that the part performed by the plant is only to furnish a substratum in which the micro-organisms may live. In the fluid of the secreting organs of *Pinguicula vulgaris*, *Drosera rotundifolia* and *longifolia*, *Dionaea muscipula*, and *Nepenthes Mastersi* several forms of bacteria were found, all being able to peptonize the albumen, and they were always living in the fluid. If these results prove to be correct, which is hardly to be anticipated, the theory of the digestive power of these plants together with

[14] Acta Horti Petropolitani XII, 1–19.

many biological explanations and theories will need alteration. —J. CHRISTIAN BAY.

The phylogeny of ferns.

A late paper by J. Bretland Farmer will be found to contain suggestions of special importance to botanists interested in the phylogeny of the Filices.[1] Mr. Farmer finds that the divisions of the neck canal cell of the archegonium into two by a definite, transverse wall is by no means invariable. This has been observed by Dr. Douglas H. Campbell as an occasional occurrence in Osmunda, which this author has shown to be in many respects transitional between the eusporangiate and leptosporangiate Filicineae. The doubling of the nucleus in the canal cell in species of typical leptosporangiate Filicineæ (Polypodiaceæ) has been observed frequently. These facts suggest strongly the condition of things that obtains in the neck canal cell of the liverwort archegonium. The basal wall in the young embryo is formed as in Isoetes and Equisetum, at right angles to the long axis of the archegonium. The manner in which the young sporophyte issues from the oophyte distinguishes Angiopteris from those other ferns whose embryology is known. The cotyledon and stem burst through the upper surface of the prothallium, the root boring downwards through it, while in the other ferns the cotyledon and stem issue from the lower surface through the archegonial region, and grow up around the edge of the prothallium. The prothallium is very much like the thallus of Anthoceros, with which it is often associated.

These facts add more weight to the view that the eusporangiate ferns are the more primitive and that the ancestors of the Filices were closely connected with, if not derived from, the ancestors of such liverworts as Anthoceros.

It is to be regretted that Mr. Farmer's material was insufficient to make a thorough and critical study of that phase of the life history of the plant in question.—D. M. MOTTIER.

[1] On the Embryogeny of *Angiopteris evecta* Hoffm.: Annals of Botany VI. 265 (October, 1892).

BRIEFER ARTICLES.

The flowers of the horsechestnut.—The fertilization of our common horsechestnut (*Æsculus Hippocastanum*) is an extremely interesting study.

The flower-clusters are terminal and of mixed inflorescence. At first sight the flowers on the individual branches appear to be arranged in racemes, as well as the branches themselves, but this cannot be the case, as the flowers are all on the upper side. The lowest flower opened first and was originally the terminal one. From its pedicel arose a lateral branch, also terminated by a flower, and this process went on, till the cluster contained, on an average, about eight flowers. The method of growth is the same as that of the leafy branch of the tree, where the stronger axillary bud of the pair next the flower-cluster throws its mate to one side, making it appear lateral instead of terminal.

There are many flowers in a single thyrsus. The branches average about twenty-five on my tree, with an average of eight flowers to a branch. There are more flowers on the lower branches, for they have more time to develop. The first flowers to mature are all staminate having a rudimentary pistil only. Later, other flowers with perfect pistils appear, and these are proterogynous, the style protruding from the bud. As far as my observations extend, these are from the fourth to the sixth flowers on the branch, the later ones being exclusively staminate. They generally appear on the lower branches. The stamens in the pistillate flowers are perfect and discharge their pollen. Müller mentions a case where the stamens do not discharge, as in the maples, but I have never seen this in the horsechestnut.

The nectar in the flower is secreted by an hypogynous disk. The corolla has four or five petals; when there are but four the lower petal is absent. Each petal has a claw and two projections where the blade joins the claw. These projections are pressed tightly against the stamens, and serve to protect the nectar from the rain, and to close the path to creeping insects. The petals are white, with yellow nectar guides, which change gradually to a beautiful crimson. The colors of the cluster are therefore variegated, the older flowers having crimson, the younger yellow spots, with varying shades of color according to the age of the flower. This change of color appears to keep the bees informed which flowers are not worth visiting, for I have never seen a bee waste his time by crawling into a deeply crimson spotted flower. The entrance to the nectar is at the base of the two upper petals, the path below being cut off by the projections on the petals and the position of the stamens.

The stamens are usually seven, and are at first declined. They rise one by one as they mature, and, if we are looking at the right time, we can see the anther of a stamen that has just risen split suddenly and become covered with pollen. When this takes place, the anther stands directly in the path to the nectar.

If we number the stamens, beginning at the upper right hand stamen and continuing in the direction of the hands of a clock, and then watch the order in which the anthers mature, we shall find that it is in one of the two following series, 3, 5, 4, 7, 2, 6, 1 or 5, 3, 4, 1, 6, 2, 7. One these series is the reverse of the other, for if we count in the first instance from right to left, beginning at the upper stamen on the right side of the flower, and in the second case from left to right, beginning at the upper left hand stamen the series of numbers will be the same. We can explain this by regarding the stamens as formed from two condensed cycles of staminate leaves, arranged on the two-fifths plan, with the three upper stamens belonging to the first cycle suppressed, leaving no. 3 and 5 only of this cycle of stamens, while the other five belong to the second cycle. On this hypothesis, the order of dehiscence follows the two-fifths plan, as any one may easily study out for himself. Normally, the stamens of the second cycle would stand in front of those of the first cycle, but the rule followed seems to be that the stamens arise where there is most room in the flower-bud and cause the cycles to alternate.

According to my observations, the missing stamens are the three upper ones of the outer cycle. Eichler, in his Blüthen-diagramme gives them differently. It is quite possible that different stamens may be suppressed in different localities, and the order of dehiscence in that case would be an interesting study. There is one curious little fact relating to this theoretical explanation. The stamens numbered 3 and 5 always mature about the same time and some hours before the rest, which then follow each other closely. Might this be because they belong to the outer cycle of which two succeeding members are suppressed?

It is very clear that a bee entering the flower would brush against the stamens and become dusted with pollen, and would leave this pollen on the style of the next pistillate flower visited, for the style curves upward and stands in exactly the same relation to the path to the nectar as do the stamens. I believe the flowers, however, to be self-fertile. The honey-bees have a wicked way of crawling about under the flower and stealing the nectar, but the humble-bees appear to visit the flower always in the proper way.

A very interesting adaptation in the horsechestnut is the presence

of well-developed buds in the upper axils of the leaves in the buds containing flower-clusters. These start at once in the spring and while the flower-cluster is still young become rapidly growing branches, while the leafy branches without flower-clusters have merely latent buds in their axils. When the flower-cluster drops off a new branch is ready to carry on the old one, which has been stopped in its growth. It is an interesting speculation as to the reason of this growth of the axillary bud or pair of buds. Perhaps it is able to take place because the development of the flower-cluster requires less nourishment.—JANE H. NEWELL, *Cambridge, Mass.*

Francis Wolle.—We regret to announce the death of the Rev. Francis Wolle, which took place at his home in Bethlehem, Pa., on February 10th, after long and paiefnl illness. Mr. Wolle was born in 1817, at Jacobsburg, Pa. From 1839 onward his life was devoted to the educational work of the Moravian church, with the exception of a few years of mercantile pursuits. For twenty years, from 1861 to 1881, he was principal of the Young Ladies Seminary at Bethlehem, and for five years previous served in practically the same capacity as assistant to his brother who was principal. In 1881 infirmity compelled his retirement from these active duties.

Mr. Wolle's interest in botany dates from about 1870. He first took up the study of phanerogams in which he received much assistance from Messrs. Robert and Eugene Rau, of Bethlehem. Later Mr. Wolle engaged in the study of mosses in connection with Mr. Eugene Rau. His interest was drawn to the fresh water algae, in connection with which his name will be best known, on obtaining the beautiful work of Dr. H. C. Wood on fresh water algae, published by the Smithsonian Institution. He soon entered into correspondence with Dr. Wood and Prof. Farlow in this country; later he received much encouragemeet and assistance from Rabenhorst, Wittrock, and Nordstedt abroad, in a study which became of engrossing interest. His industry in making known our fresh water flora resulted in the publication in 1884 of his "Desmids of the United States," containing 1,100 figures on 53 colored plates. This work was practically continued in 1887 by the publication of two volumes, one of text and one of plates, on the "Fresh Water Algae of the United States," in which we have over 2,300 figures on 157 colored plates. In 1891 appeared the volume of illustrations of the "Diatomaceae of the United States," 2,300 of which fill 112 plates, and in 1892 a revised edition of the "Desmids." These works, imperfect as such pioneer labor must necessarily be, will remain as a monument of untiring industry; and when it is remembered that Mr. Wolle was his own artist, the amount

of really valuable work that he accomplished in the twenty years of his attention to botanical subjects is little more than marvellous. Of course Mr. Wolle fell into some errors from which a scientific training would have delivered him, but, spite of these, the immense value of his contributions to the knowledge of our water plants can never be forgotten.

It may be of interest also to know that Mr. Wolle was the first patentee, in 1852, of machinery for making paper bags.

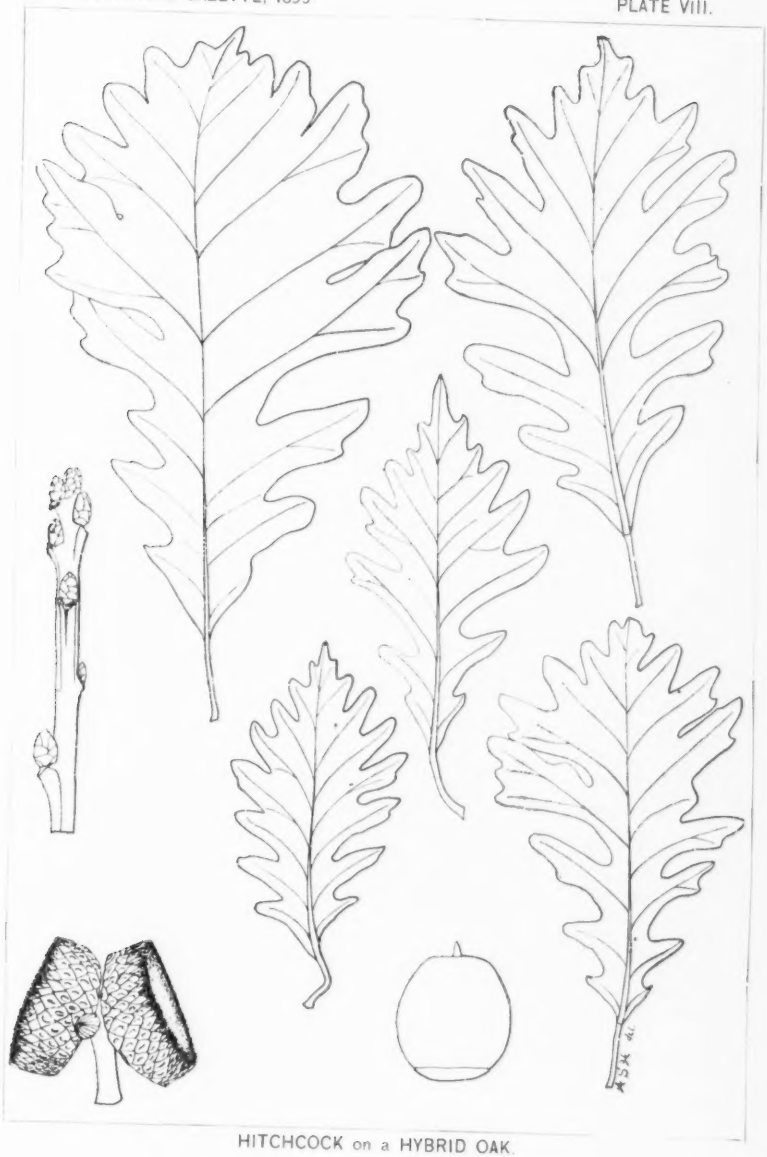
We are indebted to Mr. Eugene A. Rau for papers and memoranda from which the above facts are derived. We copy from the *Moravian* a brief word as to his character:

"Unvarying kindliness was a distinguishing feature of our departed Brother's character, and his sincere urbanity endeared him to many in all classes in the community, which mourns the loss of a distinguished citizen, even as the Church will cherish his memory as that of a successful educator."

Another hybrid oak.—PLATE VIII.—Last fall an oak tree was found along the bluffs of the Kansas river opposite Manhattan, which cannot well be referred to any of the American species of *Quercus* and certainly not to any of the species native of Kansas. The bark and twig characters are those of that form of *Q. prinoides* Willd. known as *Q. Muhlenbergii* Engelm., which is the common oak of the upland woods in this vicinity. The leaves, however, are intermediate between that species and *Q. macrocarpa* Michx., which is also quite common here. Some have nearly the size and shape of the latter, while others closely resemble rather deeply lobed forms of *Q. prinoides*. But they are all pubescent beneath and have the coriaceous texture of *Q. prinoides*. The acorn is also intermediate between the two species mentioned, being much larger than that of *Q. prinoides*, and showing a tendency to be mossy fringed. The drawings were made from this specimen.

Another tree which is apparently the same form was found on the bluffs of the Blue river about three miles above Manhattan by Prof. Mason and the writer. This agrees with the first specimen except that the cups of the acorns are deeper, more turbinate at base and decidedly mossy fringed as in *Q. macrocarpa*.

These two specimens are, in the opinion of the writer, hybrids between *Q. macrocarpa* and *Q. prinoides*. The two supposed parents are abundant in this region and are the only members of the white oak section found in this part of the state.



HITCHCOCK on a HYBRID OAK.

THE
JOHN CRERAR
LIBRARY

Hybrids among the white oaks are not common. *Q. macrocarpa* hybridizes with *Q. alba*,[1] but I find no record of a hybrid between *Q. prinoides* and any other species although Vasey records one between *Q. alba* and *Q. Prinus*.[2]

Plate VIII shows the twig, acorn and two cups natural size, and leaves one-half natural size.—A. S. HITCHCOCK, *Kansas State Agricultural College, Manhattan.*

A graft hybrid.—The following example of graft hybrid came under my observation two or three years ago. The number of such cases is so small that it is perhaps worthy of description. The plant belonged to Mrs. Dixson, at present librarian of the University of Chicago. The following is her description of the method she used in grafting: "I took two strong healthy plants, one a pure white and one a pure red (single bloom geraniums) and grafted them together at the root in length sections using common grafting wax and binding with long strips of flannel. The first year there was little accomplished except to keep the plant alive. In the fall I planted it in the sunniest corner of the room with plenty of rich soil. It grew rapidly and soon flowered profusely. At first there were red flowers with blotches of white, sometimes one perfectly white petal and all of the others red. The second summer the two plants were fairly wedded into one life on conditions of absolute equality. The heads would show red and white in almost equal proportion. I remember one cluster with three white flowers, two mottled ones and the rest pure red. It lived for four years and grew to be such a bush that it had to be trained against the porch rail."

At the time I saw the plant the mixture of red and white was even more marked than the condition which Mrs. Dixson describes. One blossom had two red petals and the rest white, another had some pure red and the other mottled with white, etc. I could not discover that either plant seemed to have influenced the hybrid any more than the other one had. They were certainly fairly "wedded together."—HERBERT L. JONES, *Cambridge, Mass.*

[1] Engelmann, Trans. St. L. Acad. Sci. III. 397. E. Hall, Amer. Ent. and Bot. 1870. 191.

[2] Bull. Torr. Bot. Club x. 25, 26.

CURRENT LITERATURE.

A notable collection of Hepaticæ.[1]

Dr. Richard Spruce, whose work on the Hepaticæ of the Amazon and the Andes of Peru and Ecuador[2] forms the most elaborate and extensive work in systematic hepaticology in recent times, has supplemented this work by issuing the most extensive series of exsiccatæ that has yet appeared among the Hepaticæ. The series represents the arduous labors of Dr. Spruce in the Andes and the valley of the Amazon, where he spent fifteen of the best years of his life in a study of that equatorial flora. It numbers 478 specimens, finely preserved, mostly in a fruiting condition, or at least with perianths which furnish most available taxonomic characters, and in abundant quantity. It will be well for those whose hepatic horizon is limited by the structure of Marchantia polymorpha, and who conceive it to be a representative hepatic, to take notice that of the above number less than a dozen are of the marchantiaceous type, and there is even a smaller representation of the other thallose groups of which Anthoceros and Riccia are types, while the foliose Jungermaniaceæ constitute the great bulk of the series. The great genus Lejeunea alone with its formidable array of sub-genera appears under 175 numbers. The student who sees only the depauperate remnant of this genus as represented in temperate latitudes, fails to form any conception of its extent or true character; some of the forms are truly luxuriant, and the diversity presented by extreme types is at first glance a point in favor of generic instead of sub-generic division of the genus; further study, however, reveals a closeness that precludes this unless it be for convenience, which is at best a weak ground for the establishing of genera.

The further study of the collection has enabled Dr. Spruce to correct some references of species that were made in his monograph, and a number of new species appear which are not accompanied by descriptions, and hence are *nomina nuda* until published, which the good Doctor will doubtless attend to at once. To show the relative number of the species of the monograph which are represented in the exsiccatæ we have made the following comparisons in the genus Plagiochila which, next to Lejeunea, is the largest and most representative of the South American flora. Sixty-nine species were described in the monograph, of which thirty-nine were described as new by Dr. Spruce; in the exsiccatae sixty-eight species appear, of which fifty-

[1] Hepaticæ Spruceanæ Amazonicæ et Andinæ, annis 1849–1860 lectæ. Malton, 1892.

[2] Trans. Bot. Soc., Edinb., xiv, 1–590, t. i–xxii (1885).

three are of the number described in the monograph, but representations of eleven of Spruce's new species are lacking. Of the fifteen species remaining, seven are now issued as new species, while the other eight represent species previously described by others.

The present work is a crowning effort of a busy life now turning seventy-five years. Long may its author be spared to complete other problems in the systematic study of his favorite group of plants.

L. M. U.

Two monographs on Characeæ.

Within a very short time of each other there have come to our table the first fascicle of each of two monographs dealing with the Characeæ of widely separated localities, namely, America and Australasia; the one by Dr. T. F. Allen, of New York City, the other by Otto Nordstedt, of the University of Lund, Sweden.[1]

The first part of Dr. Allen's Characeæ of America received high commendation. It is quoted in the introduction to Norstedt's present work as furnishing "the best introduction, in English, to the anatomy, morphology, and classification of the order." The illustrations in the present fascicle of part II, which are always the part of such a work first scanned, are very well executed. Six of them are photo-engravings by the half-tone process (erroneously spoken of in the text as "photogravures") representing mounted specimens of the plants half or full size, while the eight lithographic plates represent the habit of single plants and details of the fruit and leaves. It is unfortunate that the plates are not numbered; and it would seem that the photo-engravings deserved to have the name of the species inserted on the press rather than with a rubber stamp.

Of the character of the text we are not competent to speak except on general principles, and on these it would seem to be open to adverse criticism. And first as to typography: Dr. Allen should select and adhere to some uniform scheme for each description, and by style of type and arrangement of matter make it easier for the eye to catch the items that are sought. For instance: in one place the list of synonyms is indented, in another they are flush with the name of species; in one place we have "NITELLA OBTUSA, *Spec. nov.*," in another "NITELLA MONTANA, Sp. nov.," and in a third NITELLA MISSOURIENSIS, N. SP.;" in one description occurs a list of "LOCALITIES," while in the remainder they are embodied in the general text with no heading.

[1] ALLEN, TIMOTHY F.—The Characeæ of America, part II, fascicle I. Roy. 8vo., pp. 8, pl. 14. The author: New York. $1.00.

NORDSTEDT, OTTO.—Australasian Characeæ described and figured. Part I. 4to. pp. 24, pl. 10. Friedländer & Sohn: Berlin, 1891. 7 shillings.

Such things as this, together with the lack of uniformity in the capitalization of names and the abundant typographical errors, mar the appearance of the text very much.

It would seem, in the second place, to one not a student of this group, that there was a great lack in uniformity of description of the species. Contrasted characters, or description of the same points in each species, seem to us almost indispensable for sure identification. Moreover, in modern descriptions of Characeæ we notice that measurements abound, and it would seem that additional data of this kind should be given.

These criticisms may seem trivial; but if heeded we believe that the work, which we have long looked forward to, will be even more useful than it now promises to be; and it goes without saying that every one who undertakes to name these plants must have it in his library. It is privately published and we hope the author will be liberally patronized.

Turning to the Australian work, which comes to us through the courtesy of Baron Müller, we remark that its size permits more letter press as well as larger and handsomer plates, though for practical purposes probably not better. In the text, however, we have much better arrangement and typography, as well as fuller descriptions, which are English. A key to the species of Nitella would have been useful, though probably impossible at present, from the mode of publication and the imperfection of collections. Mr. Nordstedt has undertaken the work at the solicitation of Baron Müller, who has done so much to make known the Australian flora.

It is to be hoped that both of the important monographs thus begun will be rapidly pushed toward completion.

NOTES AND NEWS.

A NEW Cycas from the island of Formosa is described and figured in the January number of the *Journal of Botany*.

DR. GEORGE VASEY died at his residence in Washington, March 4th. A biographical sketch will appear in an early number of the GAZETTE.

MR. F. V. COVILLE, heretofore Assistant Botanist in the Department of Agriculture, has been appointed chief of the Division of Botany, *vice* Dr. Vasey, deceased.

RARE AMERICAN plants recently illustrated in *Garden and Forest* are Galax aphylla (Dec. 21), Agave angustissima (Jan. 4), Aster turbinellus (Jan. 11), and Salix balsamifera (Jan. 18).

DR. J. T. ROTHROCK has severed his long connection with the botanical work of the University of Pennsylvania, and has become general secretary of the Pennsylvania Forestry Association.

THE *Bibliotheca Botanica*, heretofore published by Theodor Fischer in Cassel, is hereafter to be published by Erwin Nägele in Stuttgart. It will be edited as heretofore by Drs. Lürrsen and Hänlein.

PROF. J. C. ARTHUR'S paper on "The gases in living plants", read by appointment at the Washington meeting of the American Association, has appeared in the *American Naturalist*, beginning with the January number.

THE INFLUENCE of the salts of phosphoric acid upon plants has been studied by Herr C. Loew in the case of Spirogyra. He found that it stimulated the development of chlorophyll and the general activities of the cell. In his experiments disodium phosphate was used.

M. E. GAIN has been conducting some experiments to discover the relation of moist soil and moist atmosphere to plant development. A brief summary is as follows: dry air is very favorable to the production of flowers, and moist soil is favorable; dry soil is unfavorable, and moist air very unfavorable to flowering.—*Comptes Rendus.*

MEEHAN'S MONTHLY began its third volume with the new year, and its opening number presents a colored plate of Opuntia prolifera. The leading papers, treating of notable North American plants, are valuable from the amount of information they bring together; and the smaller notes which follow contain information too important to be lost.

THE INITIAL NUMBER of the *Bulletin de l'Herbier Boissier*, under the editorial direction of M. Eugène Autran, is before us. It contains thirty-two pages and two most excellent plates. The two papers are as follows: The genera Achatocarpus and Bosia and their place in a natural system, by Schinz and Autran; and Plantæ Postianæ, by George E. Post.

MR. F. H. KNOWLTON, in an interesting paper in *Science* (Jan. 13), calls attention to the former existence of the genus Artocarpus (bread-fruit trees) in North America. As late as early Pliocene or late Miocene bread-fruit trees existed as far north as Oregon. Eucalyptus is a genus with similar history, formerly existing in North America, but compelled to disappear with changing climate.

M. LOUIS MOROT'S *Journal de Botanique* continues to be full of interesting and valuable material. The number for Dec. 16th contains a new genus of Hymenomycetes, *Sirobasidium*, by Lagerheim and Patouillard; a new genus of Chinese lilies near Polygonatum, called *Aulisconema*, by Hua; a continuation of the monograph of the Orchids of France, by Camus; and the concluding part of the lichens of Carissy and neighborhood, by l'abbé Hue. The first number of the new year contains the initial part of a paper by Guignard on the development of the seed and especially the seed-coat, the present number dealing only with certain Cruciferæ; and a discussion of the relationships of the tribe Clusieæ from a general morphological and anatomical study, by Vesque.

MR. M. L. FERNALD, assistant in the Gray Herbarium, expects to spend a portion of the coming summer studying the flora of northern Aroostook county, Maine. If there seems sufficient demand, he will collect sets of the plants of this region for distribution. The endeavor will be to secure fine specimens rather than a large number of species. It is hoped that an interest may be felt in this region which has already furnished many rare and a few new species.

IN A PAPER on the influence of parasitic fungi on their host plants[1] Mr. J. H. Wakker divides such fungi in accordance with the mode in which they influence the nutrition and growth of the hosts into four groups: *kleinophytes*, of which the only effect is chemical; *hypertrophytes*, which produce hypertrophy of the parts attacked; *isotrophytes*, with but slight chemical and direct effect; and *atrophytes*, which produce atrophy of important organs, commonly of the flower parts. His investigations concern themselves chiefly with the second group.

WITH THE beginning of this year the *Botanische Zeitung* entered upon its second half-century of existence. Advantage has been taken of this period to make some changes in form and arrangement of matter. It is now appearing in two sections, the first issued fortnightly, with single column pages more heavily leaded, devoted exclusively to the publication of complete original articles; the second retaining the original form, weekly, and devoted to reviews of current literature.

DR. J. S. NEWBERRY was not a professional botanist, but his death recalls the important services he has rendered to the science of botany. Being connected with the early explorations of our western territory he had ample opportunity to collect and put upon record many new plants and interesting observations. His chief botanical attention seems to have been given to trees, and his report upon the forest trees of Northern California and Oregon is the most complete ever published. Torrey's *Newberrya* (an Ericaceous genus of two species), of the Cascade Mountains of Oregon and the coniferous forests of Northern California, commemorates his services.

IN A PAPER touching on some points in the anatomy and physiology of the Fucoideæ[2] Barthold Hansteen describes the anatomy of Pelvetia and Sargassum, and devotes attention particularly to the assimilation products of Fucus. He concludes that a widely distributed aldehyde called fucusol, having a composition of $C_5H_4O_2$, represents the primary assimilation product; and this aldehyde bears the same relation to the first visible product, fucosan, that formic aldehyde does to starch in the higher plants, though the granules of fucosan are probably not the direct product of the chromatophores, as is the starch of higher plants, but rather the product of accumulation by the phæoplasts, which are found not only in the assimilatory system but also in the sieve-cells and the storage tissues.

---

[1] Pringsheim's Jahrbücher f. wiss. Bot. XXIV. 499.

[2] Pringsheim's Jahrbücher f. wiss. Bot. XXIV. 317.

BOTANICAL COLLECTION FOR SALE.

Among the collections of the late **Dr. Carl Sanio** in Lyck, Germany, who lately died, the following are offered for sale. 1—General herbarium—about 40,000 specimens of European plants, collected by Dr. S. or obtained by exchange. 2—Fungi—1,700 specimens. 3—Smaller collections of Lichens and Filices. 4—1,320 wood-sections for microscopical study. 5—An entomological collection of 11,000 numbers. All the collections are very well preserved in every respect, and their good condition is vouched for by Prof. Ascherson, of Berlin. All questions will be answered and a detailed account of the collection given by

J. CHRISTIAN BAY, Missouri Botanical Garden, St. Louis, Mo.

SPRAY
YOUR
FRUIT TREES
& VINES
Wormy Fruit and Leaf Blight of Apples, Pears, Cherries, and Plums prevented; also Grape and Potato Rot—by spraying with Stahl's Double Acting Excelsior Spraying Outfits. Best in the market. Thousands in use. Catalogue, describing all insects injurious to fruit, mailed Free. Address
WM. STAHL, Quincy, Ill

AGENTS $50 to $100 —A— WEEK.

Ladies or Gents. Best seller known. Needed at every house; place of business or farm the year round. "Home" Electric Motor runs all kinds of light machinery. Cheapest power on earth. Connected instantly to wash or sewing machine, corn sheller, pumps, fans, lathes, jewelers' or dentists' machinery, &c. Clean, Noiseless, lasts a life-time. No experience needed. To show in operation means a sale. Guaranteed. Profits immense. Circulars free.

W. C. HARRISON & CO., Columbus, O.

LICHENS

Of New Bedford, Mass. and Vicinity.

BY HENRY WILLEY.

Paper, pp. 39. Sent by mail for 50 cents.

NO DISCOUNTS.

The Botanical Gazette.

1893: Eighteenth Year of Publication.

A JOURNAL of varied botanical information, embracing all departments of the science, containing not only technical articles, but many of general biological interest, and news regarding botanists and their doings.

The current year promises to be a most notable one in the history of American botany, and the GAZETTE will, as in the past, faithfully reflect the activity of the botanical world. The notes and news column will be especially valuable this year to those who desire to keep informed of the numerous important botanical gatherings which are to take place.

$2.50 per Year; Single numbers 25 cents each.

Published by the Editors: JOHN M. COULTER, Bloomington, Ind.
CHARLES R. BARNES, Madison, Wis.
J. C. ARTHUR, La Fayette, Ind.

NOW READY.

THE "NORTH AMERICAN PYRENOMYCETES."

By J. B. ELLIS and B. M. EVERHART, with original illustrations by F. W. ANDERSON; one thick octavo vol., over 800 printed pages, 41 full page, tinted plates. 2500 North American species of the old genus "Sphæria" described and arranged in accordance with the modern ideas of classification. The vol. is bound in fine cloth with stamped covers and gilt lettered back. **Price, $8.00,** with 35 cents additional if sent by mail. Address,

J. B. ELLIS, Newfield, N. J.

Publications of the Torrey Botanical Club.

(1) THE BULLETIN.

This journal has been published consecutively since 1870, beginning with four pages monthly, gradually increasing, until in 1892 over 32 pages monthly with many full page illustrations were issued. The subscription price is $2.00 per annum.

(2) THE MEMOIRS.

The subscription price is fixed at $3.00 per volume in advance. The numbers can also be purchased singly and an invariable price will be fixed for each. Volumes I and II with four parts each, and Nos. 1 and 2 of Vol. III have already been issued.

(3) The Preliminary Catalogue of the Anthophyta and Pteridophyta reported as growing within one hundred miles of New York, 1888. Price, $1.00.

Communications should be addressed to

Editors of the TORREY BOTANICAL CLUB,
Columbia College, New York City.

SCIENCE (Weekly.) $3.50 per Year.

Eleventh year (1893). More than 1000 of the leading scientific men and women of America and Europe have agreed to contribute.

Communications will be welcomed from any quarter. Abstracts of scientific papers are solicited, and twenty copies of the issue containing such will be mailed to the author on request in advance.

N. D. C. HODGES, 874 Broadway, New York.

Journal of the New York Microscopical Society.

PUBLISHED QUARTERLY.

Address Rev. J. L. ZABRISKIE, Waverley Ave., Flatbush, L. I., N. Y.

In United States and Canada, **One Dollar** a year.
In Great Britain and Europe, **Five Shillings** a year.

R. FRIEDLÄNDER & SOHN, Natural History Booksellers,

Berlin (Germany) N. W. Carlstr. 11,

have published every fortnight, since 1879:

Naturae Novitates: Natural History News.

Bibliographic List of the Current Literature of all Nations on Natural History and Exact Sciences.

Price $1 per year (52 Nos.) post-free. Specimen-number gratis on application.

1893, fourteenth year of publication.

Back volumes, each complete with index, still to be had.

CHARACEAE OF AMERICA.

The first fasicle of the second part of the **Characeae of America** is now ready. It contains descriptions of eight species of Nitella, as follows: **Nitella opaca** Ag., **obtusa** Allen, **montana** Allen, **Blankinshipii** Allen, **Missouriensis** Allen, **flexilis** Ag., **subglomerata** A. Br., **and glomerulifera** A. Br., with fourteen full-page illustrations (eight lithographic plates and six photogravures.) These fasicles will be issued from time to time as plates can be prepared. Price of each part $1.00—the actual cost if the whole edition of 500 copies be sold. Address

T. F. ALLEN, 10 East 36th St., New York City.

PLANTS FOR SALE.

The late Dr. F. Blanchard of this city, formerly of Vermont, left an herbarium of about 2,000 species of mounted plants, and about 3,000 species unmounted, the latter mostly duplicates, including many duplicate mosses. They are chiefly eastern plants, with a mixture of nortwestern ones obtained by exchange, and are for the most part first class specimens. Bids are invited, either for the whole or for a part. As a nucleus of, or an addition to a College collection they will be especially valuable. For further information address

GEO. VASEY, OR J. M. HOLZINGER.
WASHINGTON, D. C.

SPECIALLY PREPARED

Herbarium Paper FOR Botanists

This paper is offered at the moderate price of $5.50 per ream. We also furnish—

No. 1 Genus Cover,	16½ x 24 inches,	at	$4.00	per 100
2 "	" "		2.50	"
3 "	" "		1.50	"
Dryers,	12 x 18 "		2.00	"
Species sheets,	16½ x 23½ "		.50	"

Orders will receive prompt attention. Write for samples.

E. MORRISON PAPER CO.,
1009 Penna. Avenue, N. W., Washington, D. C.

BAUSCH & LOMB OPTICAL CO.,

MANUFACTURERS OF

MICROSCOPES, TELESCOPES,

PHOTOGRAPHIC LENSES,

AND OTHER OPTICAL INSTRUMENTS

Factory and Office ; ROCHESTER, N. Y.—531-543 N. St. Paul Street.
Branch Office ; NEW YORK.—48-50 Maiden Lane.

Thirteenth edition of illustrated catalogue, with a number of improvements and additions in the line of microscopes, will be sent free on application to any person interested in microscopy.

QUEEN & CO.,

Microscope Makers,

PHILADELPHIA.

MAGNIFYING GLASSES. (Special rates in dozen lots.)

BEST ACHROMATIC TRIPLET. ($5).

PLANT PRESSES (and Paper).

BOTANICAL COLLECTING CASES.
($1.25 to $1.75.)

GRAY'S BOTANICAL MICROSCOPE.
($1.40 and $1.65.)

THE "ACME" MICROSCOPES,
Of finest Workmanship.

GRAY'S MANUAL, (to close stock at these "cut rates," mailed free. Manual $1.62. Pocket Ed. $2.00. Lessons & M. $2.16.)

Send for complete Catalogue B. QUEEN & CO., Philadelphia.

Henry Heil Chemical Co.,

ST. LOUIS, MO.

Chemicals and Apparatus

AND

LABORATORY SUPPLIES.

GIVE US A TRIAL. YOU WILL FIND US PROMPT AND CHEAP

Before Ordering Elsewhere, Get Our Quotations.

Large Illustrated Catalogue on Application.